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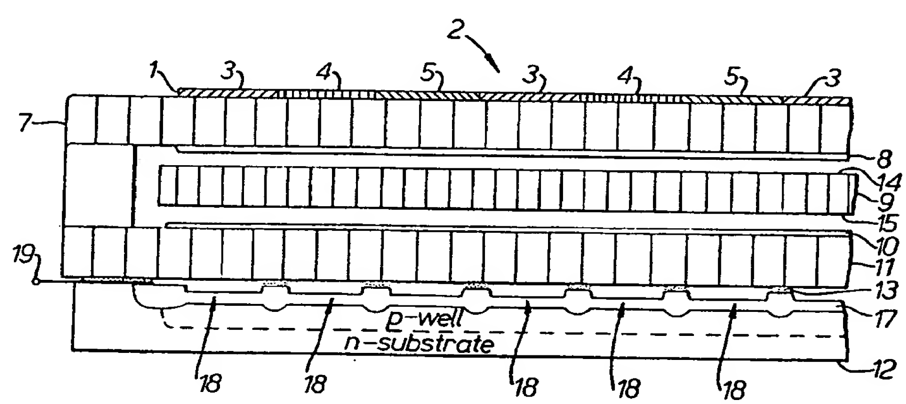
(54) Electro-optical converters

(57) An electro-optical converter is arranged to retain the colour content of a very low intensity optical image and may form part of a low light television camera. The converter includes an image intensifier (9) having an input formed as a colour filter (2) having blue, green and red elements (3, 4, 5). The different colours of the incident image are greatly intensified by the image intensifier and its output is fed to a solid state optical sensor such as charge coupled device (12). The output of the device constitutes a video signal representative of the viewed scene, and its colour content can be extracted from a knowledge of which elements of the charge coupled device receive illumination from the filter elements of the different colours. The image intensifier is preferably a micro channel plate amplifier having electron multiplying channels. The filter may be formed as a fibre-optic plate (7) which prevents image spreading and crosstalk, and a further fibre optic plate (11) may be provided between the image intensifier and CCD array.



The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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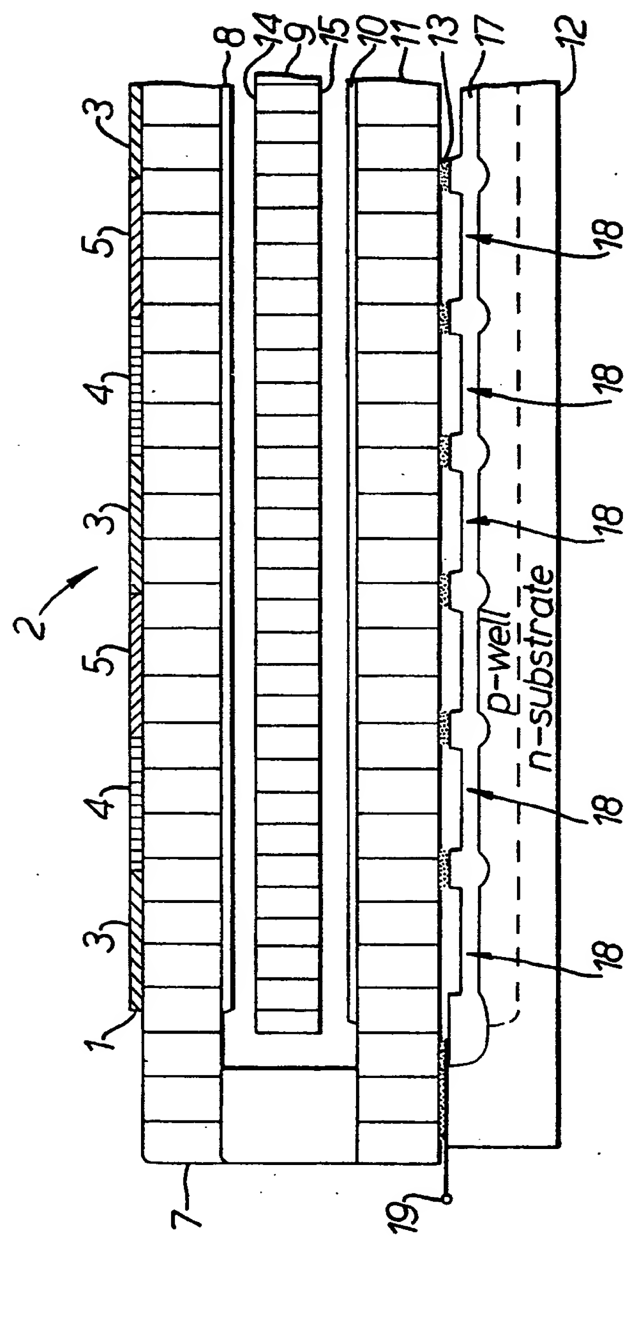

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p-well
n-substrate

SPECIFICATION
Electro-optical converters

This invention relates to electro-optical converters which operate to convert a received optical image into a corresponding electrical signal. Converters of this kind form the essential part of television cameras, for example. Although it is desirable to televise a low light scene so as to retain its colour content in the corresponding electrical signal which is generated, so as to enable, for example, the scene to be reconstituted in colour, conventional electro-optical converters such as silicon vidicons, isocons and similar camera tubes which are sufficiently sensitive to operate at very low light levels do not preserve the content of the scene. These sensitive conventional electro-optical converters are capable only of monochrome operation and the expedient of using a number of separate electro-optical converters, each to handle a predetermined colour, is undesirable as it would result in an excessively expensive and cumbersome system. Moreover, it would require the use of additional optical surfaces to separate out the different colours. In optical arrangements which receive images at very low levels of illumination, the number of optical reflecting or transmitting surfaces must be kept to an absolute minimum to avoid unnecessary optical attenuation of the wanted image.

This invention seeks to preserve an improved electro-optical converter which preserves the colour content of an image presented to it.

According to this invention, an electro-optical converter includes an image intensifier device arranged to receive an incident optical image at an input surface thereof, and to produce in response thereto a reconstituted optical image of greatery intensity at an output surface thereof; an optical filter having a plurality of adjacent co-planar colour selective elements of at least two colours and which is located adjacent to said input surface in an image receiving path; and a planar solid state optical sensor having in input surface positioned adjacent to the image intensifier device so as to receive said reconstituted image, the optical sensor being operative to generate an output signal representative of the incident optical image and which contains information enabling the colour content of the image to be determined.

The optical filter determines which areas of the optical sensor receive the different colours, and from a knowledge of this the colour content of the scene can be reconstituted. The way in which the colour information is included in the output signal depends on the electrical nature and the geometrical layout of the solid state optical sensor.

The invention is particularly suitable for receiving the very low intensity of an image obtained from a televised scene which is illuminated, for example, only by natural starlight.

The invention is further described by way of example with reference to the accompanying drawing, which illustrates a scene view of an electro-optical converter in accordance with the invention.

Referring to the drawing, an image receiving surface 1 of an electro-optical converter comprises a thin co-planar colour filter 2. The filter is formed of a very large number of adjacent colour elements 3, 4, 5 lying in a single plane and which are respectively red, green and blue, the colour sequence being repetitively repeated across the whole area of the input surface 1. The pattern can consist of very thin parallel stripes which repeat, or alternatively a fine dot pattern of colour elements can be provided. The size of the individual elements should be very small so that the sequence repeats at least once over a distance which corresponds to the finest required optical resolution of the electro-optical converter. Thus if a two dimensional coloured image is projected on to the upper surface 1, different areas of the filter 2 transmit the different colours. These transmitted colours are coupled via a fibre optic face plate 7 to a photocathode 8. The fibre optic face plate 7 forms part of the wall of an evacuated enclosure which contains a micro-channel plate amplifier 9. The filter 2 is formed on and in contact with the fibre optic plate 7, since the filter itself will generally be composed of a relatively weak gelatine or dielectric film which must be firmly supported. A fibre optic plate is used rather than a simple slab of light transmissive glass in order to prevent the image spreading and undesirable cross talk occurring between adjacent filter elements. The light which is passed by the different filter elements 3, 4 and 5 is conducted along the individual fibres to a thin photocathode layer 8 which is formed on the inner surface of the plate 7. The photocathode 8 produces electrons which have a current density which is related to the intensity of the different colours received by it, and the electron image so formed is greatly amplified by means of the micro-channel plate amplifier 9.

Micro-channel plate amplifiers are well known and briefly they consist of a thin flat plate of glass having a very large number of hollow channels extending from an input surface 14 to an output surface 15. Electrons which enter the input end of each channel are multiplied by a secondary electron process so that a very much larger number of electrons is emitted from the output end of each channel. Because each channel is of an extremely small diameter, a very fine image resolution can be produced, and because electrons do not travel from one channel to another, the effect of cross talk is minimised.

The electrons emitted by the micro-channel plate amplifier 9 are incident upon a phosphor screen 10 which is formed on the inner surface of a fibre optic plate 11 at which a greatly amplified reconstituted optical image is formed. This image is transmitted via the further fibre optic plate 11 to a charge coupled device 12. The plate 11 conveniently forms part of the evacuated

envelope within which the micro-channel plate amplifier 9 is mounted. It also forms a rigid support upon which the charge coupled device 12 is firmly mounted by means of adhesive 13.

Charge coupled imaging devices are now well known and can take a number of different forms, but briefly one common kind consists of a body of semiconductor material, usually n-type silicon, which contains wells of p-type semiconductor material positioned under an image receiving surface which consists of a layer 17 of insulating material, such as silicon dioxide. The action of light upon the charge coupled device is to locally accumulate charge in well below thin regions 18 of the layer 17 which define a regular two dimensional array of image sensitive points. The local charge corresponds to the intensity of the illumination at that point. Periodically the charges within the well are swept across the surface of the charge coupled device 12 under the control of a clock signal to an output point where they constitute an electrical output signal which is representative of the optical image. This process repeats at a frequency which determines the frame of field rate of the electro-optical converter system. Generally, the charges are read out from the two dimensional array of image sensitive points under the insulating layer in the manner of a television raster pattern to form a sequential electrical output signal at terminal 19.

From a knowledge of which filter elements 3, 4, 5 illuminate which image receiving elements of the device 12 and hence under which regions its corresponding charge is locally accumulated, it is known which portions of the output signal represents which colour. The signal can be used to form a reconstituted colour image on a suitable monitor which is adapted to receive directly such a signal, or of course, the output signal can be re-processed to convert it into the form which drive standard television-type monitors.

Any geometrical errors in the image intensifier will give rise to distortions in the illumination of the device 12. This can be overcome by illuminating the colour filter 1 of the electro-optical converter with a coloured standard optical test pattern, noting any errors in the output signal generated by the device 12, and storing the identity of these errors in a suitable store. Then during normal operation of the system, this store is accessed in step as each image point of the device 12 is scanned, and an appropriate correction factor is added to the output signal to achieve compensation.

Claims

1. An electro-optical converter including an image intensifier device arranged to receive an incident optical image at an input surface thereof, and to produce in response thereto a reconstituted optical image of greater intensity at an output surface thereof; an optical filter having a plurality of adjacent co-planar colour selective elements of at least two colours and which is located adjacent to said input surface in an image receiving path; and a planar solid state optical sensor having an input surface positioned adjacent to the image intensifier device so as to receive said reconstituted image, the optical sensor being operative to generate an output signal representative of the incident optical image and which contains information enabling the colour content of the image to be determined.

2. A converter as claimed in claim 1 and wherein the filter includes colour selective elements of three colours.

3. A converter as claimed in claim 1 or 2 and wherein the filter is formed on one surface of a thin fibre optical plate in which the individual fibres extend from said surface to an opposite major surface.

4. A converter as claimed in claim 3 and wherein a thin layer of photocathode material is located at said input surface of said image intensifier and is carried by the other surface of said fibre optic plate which is remote from said filter.

5. A converter as claimed in any of the preceding claims and wherein a fluorescent screen is located at said output surface of said image intensifier device and is present on one surface of a further thin fibre optic plate.

6. A converter as claimed in claim 5, and wherein the input surface of said planar solid state optical sensor is attached to and supported by the other surface of said further fibre optic plate which is remote from said fluorescent screen.

7. An electro-optical converter substantially as illustrated in and described with reference to the accompanying drawing.

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